ACCUMULATION OF PLANETESIMALS BY FORMING TERRESTRIAL PLANETS FROM DIFFERENT REGIONS OF THEIR FEEDING ZONE

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The model of calculations: Earlier (e.g. [1]) computer simulations of the evolution of disks of bodies coagulated at collisions were made. It was obtained in [1] that, due to the mutual gravitational influence of bodies, the mean eccentricity of orbits of bodies in the feeding zone of the terrestrial planets could exceed 0.2 during evolution. Below in the series *MeN* of runs, the migration of bodies, originally located in a relatively narrow ring, was studied under the gravitational influence of all planets (from Mercury to Neptune). In the series MeN_{03} of calculations, the masses of the embryos of the terrestrial planets were equal to 0.3 of the present masses of the planets. In the series MeS_{01} of calculations, I considered the embryos of the terrestrial planets with masses equal to 0.1 of the present masses moving in present orbits of the planets, and also Jupiter and Saturn with their present masses and their present orbits (Uranus and Neptune were excluded). The symplectic integrator from the Swift integration package [2] was used.

In each variant of calculations, 250 initial bodies were considered. The initial values a_o of the semimajor axes of orbits of the bodies varied from a_{omin} to $a_{omin}+d_a$, and the number of bodies with a_o was proportional to $a_o^{1/2}$. The values of a_{omin} varied with a step of 0.2 AU from 0.3 to 1.5 AU. d_a=0.5 AU for a_{omin}=1.5 AU. For other runs d_a=0.2 AU. In some variants of the *MeN* calculations, initial eccentricities e_o of orbits equaled to 0.05, and in other runs they were 0.3. For MeS_{01} and MeN_{03} calculations, I considered only e_o=0.05. The initial inclinations i_o were equal to e_o/2 rad. In each run only one value of a_{omin} was considered. As the mutual gravitational influence of bodies was not considered, the considered model of calculations shows minimum estimates of mixing of bodies. Collisions of bodies with planets were not simulated. The orbital elements of the migrated bodies were recorded in computer memory with a step of 500 years. Based on these arrays, similar to the calculations [3-7] of migration of bodies from outside the Mars's orbit, for the considered time interval, I calculated the probabilities of collisions of bodies with forming planets and the Moon. Compared with computer simulations of the evolution of disks of bodies coagulated at collisions, this approach allows one to obtain large statistics of the probabilities of collisions of bodies with planets or their embryos.

The total masses of planetesimals delivered to forming terrestrial planets from different distances from the Sun: Based on the calculated probabilities of collisions of migrating bodies (planetesimals) with forming terrestrial planets [8], I made conclusions on the process of formation of the planets. The embryos of the terrestrial planets with masses about 0.1 of masses of the present planets accumulated mainly planetesimals from the neighbourhoods of their orbits. Probabilities of collisions of planetesimals, originally located at distances from 0.7 to 0.9 AU from the Sun, with embryos of the Earth and Venus with masses equal to 0.3 of masses of present planets, differed for these embryos by no more than twice. The total mass of planetesimals, originally located in each of the regions of the zone located at a distance from 0.7 to 1.5 AU from the Sun, and colliding with the almost formed Earth and Venus, differed for these planets, probably by not more than a factor of two. The inner layers of each terrestrial planet were formed mainly of planetesimals from the vicinity of the orbit of this planet. The outer layers of the Earth and Venus could accumulate the same material for these two planets from different parts of the feeding zone of the terrestrial planets.

In the considered model, the Earth and Venus could acquire more than a half of their masses in 5 million years. The times could be greater for the model for which not all collisions result in coagulation. The assumption of the formation of the Mars embryo with a mass that was several times smaller than that of Mars, as a result of compression of a rarefied condensation, can explain a relatively fast growth (in not more than 10 Myr) of the main mass of Mars. With the ratio of the masses of embryos of the Earth and the Moon equal to 81, the ratio of probabilities of collisions of planetesimals with the embryos of the Earth and the Moon did not exceed 54. The formation of the terrestrial planets can be explained even with a relatively smooth decrease of the semimajor axis of Jupiter due to its ejection of planetesimals into hyperbolic orbits, without the Grand Tack model or the Nice model.

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